ARI Contractor Report 2000-04

Sustaining Rifle Marksmanship Proficiency in the U.S. Army Reserve (USAR)

Monte D. Smith
Raytheon Systems Company

January 2000

United States Army Research Institute for the Behavioral and Social Sciences

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) January 2000	2. REPORT TYPE Final	3. DATES COVERED (from. . . to) September 1998 – December 1999
4. TITLE AND SUBTITLE Sustaining Rifle Marksmanship Proficiency in the U.S. Army Reserve (USAR)		5a. CONTRACT OR GRANT NUMBER DASW01-94-D-0011/DO #0018
		5b. PROGRAM ELEMENT NUMBER 63007
6. AUTHOR(S) Monte D. Smith (Raytheon Systems Company)		5c. PROJECT NUMBER A792
		5d. TASK NUMBER 2125
		5e. WORK UNIT NUMBER C01
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Raytheon Systems Company Instructional Systems Directorate 10700 Parkridge Blvd, 2nd Floor Reston, VA 20191-4356		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue ATTN: TAPC-ARI-ID Alexandria, VA 22333-5600		10. MONITOR ACRONYM ARI
		11. MONITOR REPORT NUMBER Contractor Report 2000-04

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 words)*:

Two investigations involving 148 U.S. Army Reserve (USAR) soldiers were conducted to examine the capability of the Laser Marksmanship Training System (LMTS) (BeamHit, 1999) to support rifle marksmanship sustainment training and predict record fire qualification scores. In both investigations, LMTS was used to support realistic/comprehensive rifle marksmanship instruction, identify soldiers in need of remedial training, and deliver that training when needed, prior to qualification firing. Some evidence was also found to suggest that LMTS-based training can improve record fire qualification rates, and that qualification performance on LMTS can be used to predict qualification performance on the live-fire range. Follow-up research is underway to assess the validity of these latter two notions.

15. SUBJECT TERMS

Rifle Marksmanship Sustainment Training Laser Marksmanship Training System (LMTS)
Performance Prediction U.S. Army Reserve

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	28	Joseph D. Hagman 208-334-9390

SUSTAINING RIFLE MARKSMANSHIP PROFICIENCY IN THE U.S. ARMY RESERVE (USAR)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Sustaining Rifle Marksmanship Proficiency
In The U.S. Army Reserve (USAR)

Introduction

Prompted by an array of impinging forces, including budget cutbacks, escalating ammunition costs, reduced access to live-fire ranges, reports of substandard rifle marksmanship proficiency (San Miguel, 1998), and ever-present training time constraints, the USAR has determined to search for more effective and resource-efficient ways to train and evaluate marksmanship through the use of training devices. The goal of this initiative is the development and evaluation of a device-based rifle marksmanship sustainment training program for USAR soldier use at home station (i.e., reserve centers) on drill weekends (Plewes, 1997, Oct 9). This objective is currently being pursued through a partnership involving the U.S. Army Research Institute's Reserve Component Training Research Unit (ARI-RCTRU) and the U.S. Army Reserve Command's (USARC's) 84th Institutional Training Division (DIVIT) and Small Arms Training Team (SATT).

Each agency involved in the partnership has a set of interrelated but non-overlapping responsibilities. SATT's role is development of the training program's course of instruction (COI). ARI-RCTRU is responsible for designing the research needed for formative and final COI development and effectiveness/efficiency evaluation. And the 84th DIVIT is USARC's designated executive agent responsible for overall project coordination and conduct. The goal of all involved agencies is a sustainment training program that will produce USAR soldier rifle marksmanship proficiency levels that meet, or exceed, unit readiness requirements while minimizing the required resources (Plewes, 1997, Nov 24).

Once all stages of the device-based rifle marksmanship sustainment training program have been formalized, plans call for device use to (a) identify which soldiers are in need of sustainment training, (b) reinforce marksmanship fundamentals (i.e., steady position, aiming, breath control, and trigger squeeze) and weapon battlesight zeroing procedures, (c) enable practice record fire qualification firing with electronic targets, and, if feasible, (d) replace live-fire qualification with device-based qualification when live-fire ranges are unavailable.

The device that seems best suited to support the above usage plan, based on a relative capabilities analysis of candidate training devices conducted by USARC (Memorandum for Record, 1997, Dec 14), is the Laser Marksmanship Training System (LMTS) (BeamHit, 1999). LMTS is an indoor, laser-emitting device with which targets can be engaged using actual weapons without the use of live ammunition. Its major components include a laser transmitter, a mandrel to which the transmitter is attached/aligned, a variety of laser sensitive targets, and a laptop computer with optional printer (Figure 1). One end of the mandrel holds the laser transmitter and the other end slips into the barrel of the weapon, in this case the M16 rifle. Vibrations from the rifle's firing mechanism activate the laser when the weapon is dry fired and the location of the emitted beam is "picked up" by the laser-sensitive target(s) (Dulin, 1999) and then recorded and temporarily stored on the computer for future printout.

A distinguishing characteristic of LMTS is that it allows soldiers to train with their own weapons with the laser transmitter and mandrel attached as an unobtrusive barrel insert. The training realism imparted when soldiers are allowed to use their own weapons is a distinct advantage over many other marksmanship training devices in the Army's inventory (e.g., Multi Purpose Arcade Combat Simulator [MACS] [e.g., Purvis & Wiley, 1990; Schroeder, 1985)], Weaponeer [Schendel, 1985; Schendel, Heller, Finley, & Hawley, 1985]), and Engagement Skills Trainer [EST] [Scholtes & Stapp, 1994]). The LMTS is also relatively inexpensive and, consequently, could be fielded in sufficient quantities to most, if not all, reserve center locations. These reasons, coupled with the device's ease of setup and operation, have prompted USARC's decision to consider LMTS for use in the envisioned marksmanship sustainment training program.

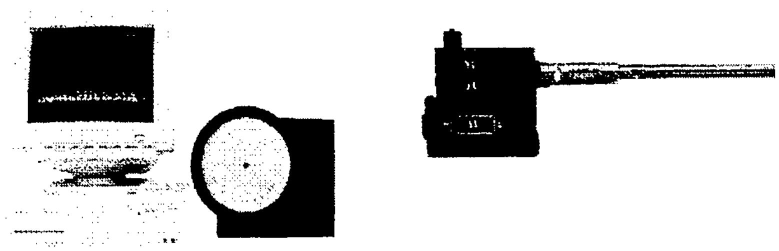

Figure 1. LMTS computer/monitor, sample electronic target, and laser transmitter with attached mandrel.

In normal operation with live ammunition, the M16 is a gas-operated weapon, which means that each time the weapon is fired, part of the gases emitted by the spent cartridge is harnessed for the purpose of extracting the spent shell, recocking the weapon, and chambering a new round. In this manner, each succeeding round is fired with no effort from the shooter other than successive pulls of the trigger. An LMTS-equipped M16, however, has a mandrel and laser transmitter inserted into the end of the barrel, precluding the use of any kind of ammunition (including blanks) unless the weapon's receiver unit is modified. Because the carrier bolt is not automatically recycled by escaping gas on an LMTS-equipped weapon, the soldier is required to manually recock the weapon after each round by recycling the charging handle, located at the rear of the upper receiver unit. This is an easy step for the soldier to accomplish, requiring a charging handle movement of only slightly more than an inch, but it does introduce a minor variation from the semi-automatic mode of fire that is used on live-fire ranges.

The semi-automatic mode of operation, as well as nearly 100% felt recoil and 50% sound simulation, can be achieved with the LMTS system by use of the M16 Blazer upper receiver group (Commander, 1999). The Blazer, dimensionally identical in weight and balance to the standard-issue M16 upper receiver, attaches to the lower receiver group of the soldier's own service weapon and allows full functionality of the bolt and ejector assemblies, thereby allowing realistic simulation of the semi-automatic mode of fire while maintaining familiar trigger take up and stock weld characteristics. Blazer ammunition is loaded via service magazines, thereby adding other elements of realism to LMTS-based marksmanship training through magazine changes (a mandatory component of live-fire qualification) and the experience of spent shell ejection.

Next steps, therefore, in developing and evaluating a device-based rifle marksmanship sustainment training program include determination of its: (a) ability to support a realistic and comprehensive rifle marksmanship COI, (b) its ability to identify soldiers in need of remedial training and to deliver that needed training as part of the COI, prior to their attempting record fire qualification, and (c) its ability to support effective sustainment training of rifle marksmanship as reflected in improved record fire qualification rates. Related to the ability to identify soldiers in need of remedial training is the device's ability to predict live-fire qualification scores. If the relationship between LMTS performance and live-fire performance is strong ($r \geq .50$), it should be possible to use LMTS performance to predict live-fire qualification scores. In this way, LMTS can be used both as a pretest to identify soldiers in need of sustainment training, and also as a posttest to identify when enough training has been provided. Once the predictor is fully developed and validated, and assuming that the LMTS-to-live-fire relationship is sufficiently robust, it is possible that LMTS qualification could be substituted for live-fire qualification.

Research Design

The overall design, consisting of three experimental and two control groups, is depicted in Table 1. All three experimental groups receive LMTS training, and they will be compared to the two control groups (collectively and individually) to determine the impact of LMTS training on subsequent live-fire qualification scores. Notice, however, that of the three experimental groups, only the first two fire the simulated 25m rifle marksmanship alternate qualification course (LMTS Alt-C). LMTS Alt-C closely mimics live-fire Alt-C, including the use of a dimensionally identical target array, identical firing distances, scoring procedures, number of allotted rounds, firing positions, and time limits. The LMTS Alt-C occurs immediately following conclusion of formal LMTS training. No actual training occurs during administration of the LMTS Alt-C, but it is possible, since it so closely simulates live-fire conditions, that it may have a positive effect on subsequent live-fire performance. A comparison between the first two experimental groups (which receive LMTS Alt-C) and Experimental Group 3 (which receives the formal LMTS COI but not LMTS Alt-C) will permit a determination of the relative importance of firing the simulated alternate qualification course prior to attempting actual live-fire qualification. If LMTS Alt-C proves to be a critical training element, another control group can be added subsequently to include LMTS Alt-C in the absence of any other LMTS training component in order to test for the relative importance of LMTS Alt-C vs the formal LMTS training components. This would provide a first approximation toward determination of the minimum amount of LMTS training needed in order to impact live-fire qualification scores.

The design in Table 1 will permit a number of other comparisons. For example, Experimental Groups 1 and 2 differ only in whether the Blazer upper receiver group is employed during training and LMTS Alt-C. By comparing Groups 1 and 2, it will be possible to determine the relative importance of simulating the semi-automatic mode of fire during LMTS training.

Comparisons of LMTS absolute training effectiveness will consist of comparing the experimental groups (separately or combined, depending upon whether any differences exist among them) with Control Group 2. This can be considered a determination of absolute training effectiveness because all three experimental groups receive LMTS training, but Control Group 2 receives no training of any kind. Relative training effectiveness will be determined by comparing the experimental groups with Control Group 1, which receives traditional (as specified in FM 23-9) marksmanship training. If the three experimental treatments are comparably effective, then the groups can be combined for the relative and absolute comparisons.

Table 1.

Data Collection Design (Acquisition and Prediction Phase).

Group	Training	LMTS ALT C[1]	Record Fire ALT C[2]
Exp 1	LMTS	Own Weapon	Live Fire
Exp 2	LMTS	Blazer	Live Fire
Exp 3	LMTS	-------	Live Fire
Control 1	Traditional[3]	-------	Live Fire
Control 2	-------	-------	Live Fire

[1]To include prior grouping and zeroing with LMTS
[2]To include prior live-fire grouping and zeroing
[3]Based on FM 23-1

For all groups in the design, prior year live-fire Alt-C scores will be collected. These scores will be used to evaluate the pretraining equivalency of experimental and control groups, and possibly to make statistical adjustments on outcome scores (live-fire Alt-C scores) in the event that the groups are not equivalent. For the experimental groups, prior year scores also will be used on a within-groups basis to evaluate performance before and after the experimental LMTS training.

As a test of retention, a 12-month, no-practice interval will be imposed on all groups, experimental and control, following collection of live-fire Alt-C scores. At the end of 12 months, Experimental Groups 1 and 2 will again be administered the LMTS Alt-C, under own weapon and Blazer test conditions, respectively, and then all five groups will undergo a second live-fire Alt-C. The null hypothesis is that after a 12 month, no-practice interval, experimental and control groups will demonstrate no differences in retention. The alternative hypothesis is that experimental groups, having benefited from LMTS training, will exhibit less forgetting and an associated reduction in the need for sustainment training after the 12-month, no-practice interval.

At the conclusion of the investigation, the objective is to have approximately $N = 200$ soldiers in each of the five rows shown in Table 1. Because of the scope of the investigation, it is not possible to collect all the data simultaneously. Thus data collection will be conducted in stages through a coordinated sequence of data collection "stops," making use of available reserve units as they become available for participation. This first report provides details of the first two data collection stops, both part of Experimental Group 1, which means that all participants received LMTS training, used their own weapons for the LMTS Alt-C component, and then went to a range for live-fire qualification trials.

Experiment 1

Method

Participants

Eighty-three USAR engineers participated in both the LMTS COI and the live-fire phases of this investigation during Annual Training (AT). None of whom had trained with LMTS prior to their research participation.

LMTS COI

The COI is closely correlated with FM 23-9 task requirements (Headquarters, 1989), including M16A2 weapon familiarity drills, immediate-action procedures, loading and unloading magazines, front and rear sight adjustments, application of the four fundamentals of marksmanship (i.e., steady position, aiming, breath control, and trigger squeeze), battlesight zeroing, and detecting and engaging a variety of targets, including engagement of reflective targets, interactive dry firing, LMTS grouping, and LMTS zeroing (see Appendix A for COI details). Remedial training was provided on an as-needed basis as part of the COI. The concluding exercise (for all soldiers) was a timed record fire engagement (LMTS Alt-C) using laser-equipped weapons and laser-sensitive targets. Eight members of the 84th DIVIT and SATT served as instructors.

Procedure

LMTS COI. The LMTS COI was conducted on a 25m outdoor range. Soldiers arrived at the range at 0745 and training began at 0800 with an introduction and preview of the day's forthcoming training activities by the trainers. A safety briefing followed. At 0900, the company broke into 10 subgroups to review firearms basics (i.e., magazines, ammunition, loading/unloading, weapon maintenance, immediate-action procedures, sight adjustment) and the four fundamentals of marksmanship.

Exercise 1 (Reflective Targets) commenced at 1030 hours on 20 lanes of the range. When soldiers had satisfactorily demonstrated the four fundamentals, they moved to Exercise 2 (Interactive Dry Firing) at the next training station, occupying 15 firing lanes, where the performance standard was 8 bullseye hits out of 10 shots, repeated a minimum of four times. Grouping and zeroing were accomplished using two, 5-lane computer consoles. A maximum of 27 (laser) rounds were permitted for grouping and a maximum of 18 rounds were allowed for zeroing. Soldiers who failed to group or zero within these respective limits were referred for remedial training and then returned to the formal COI sequence at the point judged to be appropriate by the remediation instructor.

LMTS training scoresheets, maintained on soldiers as they progressed through the LMTS training sequence, were used to record whether soldiers received remedial training at any time during the LMTS COI. Remedial training could be delivered at any point in the training sequence, from the initiation of the Interactive Dry Firing exercise up to commencement of the LMTS Alt-C. In most instances, soldiers were pulled off the firing line and sent to a separate remedial training station. In some instances (such as during Interactive Dry Firing), it was possible to deliver remedial training on the firing line without otherwise interrupting the standard sequence of training activities.

One reason for keeping a record of who received remedial training was that its effect(s) could not be predicted. On the one hand, soldiers identified as needing remedial training might be expected to be among the lowest performers on tests of objective marksmanship skills, such as the LMTS and live-fire Alt-Cs. The selection criterion for receiving remedial training, after all, was failure to properly apply the four fundamentals of marksmanship. On the other hand, if remedial training was successful and soldiers' marksmanship deficiencies were corrected during the remediation procedure, there might be no differences on subsequent performance measures between remediated soldiers and those who had not needed any such training.

The final training station, containing the Alt-C simulation exercise, occupied four firing lanes. Consistent with live-fire range practices, the Alt-C phase of the LMTS COI was timed, with 2 minutes allowed for firing 20 rounds from the prone supported position and another 2 minutes for firing an additional 20 rounds from the prone unsupported position. All firing was conducted using the hand-charging method described earlier, wherein a soldier manually recocks the weapon following each round. Minimum score for (simulated) qualification was 26 hits. Unlike all other phases of LMTS training, soldiers were not permitted to refire the Alt-C, and no training or coaching occurred during its administration.

Live-Fire Alt-C Qualification. Soldiers returned the following day to the same firing range for 25m Alt-C qualification firing. Grouping, zeroing, and Alt-C record fire were accomplished from the same 47-lane firing line. Grouping and zeroing were conducted using standard 25m M16A2 zeroing targets (see Figure 2 in Appendix A) and standard rifle marksmanship procedures from FM 23-9. Soldiers who failed to group within 27 rounds were removed from the firing line and sent for remediation and then were permitted to return to the firing line. After soldiers had successfully grouped, 18 additional rounds were allowed for zeroing. Soldiers unable to zero within the allotted rounds were sent for remediation and then allowed to return to the range.

Alt-C record fire qualification was conducted on 25m scaled silhouette targets (Headquarters, 1989; Appendix G). Each target contained 10 silhouettes, scaled to represent distances from 50m to 300m. Soldiers assumed the prone supported firing position and were given two 10-round magazines with instructions to fire two rounds at each silhouette. All 20 rounds had to be expended within 120 seconds (including the magazine change), and no more than two hits could be scored on any silhouette. After targets were scored by range NCOs, soldiers assumed the prone unsupported firing position and were given two other 10-round magazines and instructed to fire two additional (unsupported) rounds at each silhouette. All 20 rounds had to be expended within 120 seconds (including the magazine change), and no more than two hits could be scored on any silhouette. A minimum of 26 hits were required for qualification. Soldiers who failed to qualify on their first attempt were permitted to refire after successfully completing remediation.

Results

LMTS Alt-C

The mean ($N = 83$) simulated Alt-C qualification test score was 27.49 ($SD = 8.60$). Scores ranged from 5 to 40, and 60.2% of soldiers attained or surpassed the qualification cutoff of 26 hits.

LMTS Remedial Training

Fifty-three of the 83 soldiers (63.9%) who completed the LMTS COI received remedial training at some point during the LMTS phase of the investigation. Analyses of variance (ANOVAs) indicated no significant differences on any objective performance measure between soldiers who received remedial training and those who did not. Null outcomes, of course, are not conclusive but, in this instance, do support the notion that remedial training had beneficial effects. F-ratios for the following variables were < 1: LMTS Alt-C score, number of rounds required to accomplish live-fire grouping, number of rounds required to accomplish live-fire zeroing, total number of grouping and zeroing rounds, and live-fire Alt-C scores. The rejection region for these and all subsequent analyses was .05.

Live-Fire Qualification

The mean ($N = 83$) live-fire Alt-C score was 29.86 ($SD = 5.30$). Scores ranged from 18 to 40, and 75.9% of soldiers (63 of 83) achieved the minimum cutoff of 26 hits on their first qualification attempt. An additional 14 soldiers achieved qualification on their second or third attempts, bringing the eventual qualification rate to 92.8% (77 of 83). Of the six soldiers who did not qualify, two did not refire after their initial failure, three refired once but failed to qualify on either attempt, and one refired twice but failed to qualify on any of the three attempts. Of the 77 qualifying soldiers, 66.2% earned Marksmanship ratings, 28.6% Sharpshooter ratings, and 5.2% qualified at the Expert level.

LMTS vs Live-Fire

A comparison of LMTS (Mean = 27.49) and live-fire (Mean = 29.86) 25m Alt-C performance produced a paired-samples t-test value of $t(82) = 2.30$. Although mean scores on the two qualification firings differed by only slightly more than two points, the difference was statistically reliable. Soldiers in this investigation obtained higher scores on the live-fire Alt-C than on the LMTS-based Alt-C.

Current Qualification Rate vs Historical Qualification Rate

The qualification rate observed in this investigation (92.8%) significantly exceeded the qualification rate obtained by the same engineer company a year earlier (63.6%), $z = 10.29$. The previous year's qualification trials, however, were conducted on a pop-up target range, rather than on a 25m range with scaled silhouettes, so the two forms of marksmanship qualification were not strictly comparable.

Correlation Between LMTS Alt-C and Live-Fire Alt-C

The obtained Pearson Product-Moment coefficient of correlation between the two Alt-C firings was a nonsignificant $r(83) = .16$. An examination of a scatterplot of Alt-C scores provided no insight into this unexpectedly weak relationship. There was no evidence of a non-linear trend and no indication that data transformations were justified.

Discussion

This investigation had four principal objectives, the first three of which were training-related: (a) determine the ability of LMTS to support a realistic and comprehensive rifle marksmanship COI, (b) determine the ability of LMTS to identify soldiers in need of remedial training and to deliver the needed training as part of the COI, (c) assess the ability of LMTS to support effective sustainment training of rifle marksmanship as reflected in improved record fire qualification rates, and (d) provide, as a preliminary step in the development of a live-fire prediction model, empirical evidence concerning the LMTS Alt-C and live-fire Alt-C relationship. Results provided evidence that LMTS is capable of supporting a comprehensive and realistic rifle marksmanship COI and that the technology can be used both to identify soldiers in need of remedial training as well as to make the needed training available as part of the COI. Little support was found, however, for the other two objectives.

Ability to Support a Comprehensive and Realistic Rifle Marksmanship COI

The LMTS COI used in this investigation had all the earmarks of a comprehensive and realistic rifle marksmanship training platform. It was designed to closely correlate with FM 23-9 task requirements, and it appeared to accomplish this objective. The COI tested in this investigation begins with basic weapon familiarity drills and instruction on the four fundamentals of rifle marksmanship, continues with high-fidelity grouping and zeroing exercises, and concludes with engagement of timed targets via a simulated Alt-C. Table A-1 in the LMTS COI (Commander, 1999) provides a crosswalk between FM 23-9 task requirements and LMTS COI exercises and demonstrates that all key marksmanship training elements are addressed. Moreover, the LMTS COI organizes these fundamental task requirements into a logical training sequence that incorporates a satisfying degree of face validity.

Face validity of the COI is reinforced by training realism, which in turn is supported by the fact that soldiers use their actual weapons during training. This realism is perhaps most convincingly demonstrated by the COI's strict adherence to firearms safety standards, notwithstanding that live ammunition is never used in the LMTS program. Although nothing more harmful than laser beams leave the barrels of soldiers' weapons during LMTS training, strict adherence to firearms safety precepts during all phases of LMTS training effectively reinforces safe weapons handling procedures at all other times, including those occasions (during live-fire Alt-C) when weapons are actually loaded with live ammunition.

Participating soldiers, moreover, showed sustained levels of interest and involvement in the LMTS-based marksmanship training process. During after-action reviews (AARs), conducted at the conclusion of LMTS training but prior to live-fire qualification trials the following day, three sentiments were repeatedly expressed by participating soldiers: (1) recognition of the training team's professionalism and competency, (2) interest in technical aspects of LMTS technology, and (3) praise for the trainers' ability to pinpoint individual problems and provide on-the-spot remedial solutions.

Overall, LMTS appeared capable of supporting a realistic and comprehensive rifle marksmanship COI. It embodied high degrees of perceived face validity and realism, reinforced firearms safety precepts, and readily garnered soldier endorsements. These positive outcomes occurred notwithstanding last-minute developments that necessitated conducting the COI outdoors. The LMTS, of course, was designed for use indoors. Although there was precedent for its use outdoors, neither its manufacturers nor the training team recommends outdoor deployment.

Ability to Identify Soldiers in Need of Remedial Training

Almost two-thirds of participating soldiers received at least one remedial training session during the LMTS COI. The identification of soldiers in need of remediation was built into the COI and took place with minimal disruption to the training sequence. Beginning with the Interactive Dry Firing phase of LMTS training, objective (and quantifiable) performance criteria were used to evaluate training effectiveness. At any step in the training sequence, soldiers who failed to meet or exceed preestablished performance criteria were sent to a remedial training station where performance deficits were identified, evaluated, and corrected.

An experimental evaluation of the effectiveness of the remedial training component of the COI was not undertaken because *every* soldier with identified performance deficits was immediately sent for the appropriate remediation. Anecdotal reports from soldiers, however, coupled with their comments during AARs, indicated a high degree of satisfaction with remediation outcomes. Supportive evidence of the effectiveness of remediation was also found in a series of null outcomes when the postremediation performances of soldiers receiving remediation were compared with soldiers who never needed remediation. On every performance measure examined, remediated soldiers performed as well as those who never required remediation.

Ability to Improve Record Fire Qualification Rates

Unfortunately, this issue could not be answered conclusively because the test company had fired for record the previous year on a course with pop-up targets, and individual soldier qualification scores were not available from previous years. The available evidence, nonetheless, suggests a statistically reliable increase in marksmanship qualification rates (from 63.6% to 92.8%) following implementation of the LMTS COI.

Correlation Between LMTS and Live-Fire Alt-C

A plausible explanation for the failure to find a significant linear relationship between (simulated) LMTS Alt-C and live-fire Alt-C is that data integrity in the current investigation was, to some unknown extent, compromised by the outdoor setting in which LMTS training (and Alt-C firing) was implemented. LMTS was designed specifically for indoor use, and yet, due to uncontrollable circumstances, the current investigation had to be staged on an outdoor firing range. It is commendable that the LMTS technology was sufficiently adaptable, and the training team sufficiently flexible, to support outdoor implementation, but the fact remains that the current LMTS technology was never intended for outdoor use and the possibility exists that LMTS Alt-C scores in this investigation may have been compromised by the inappropriate data collection setting. It is imperative to conduct future investigations in suitable indoor facilities, or else to incorporate setting (indoor vs outdoor) as an experimental variable.

Conclusions

This investigation lent support to the notion that LMTS is capable of successfully supporting a realistic and comprehensive rifle marksmanship COI and that the COI can be used to identify soldiers in need of remedial training and permit the delivery of this training (through LMTS technology) as part of the COI. Although not demonstrated conclusively, LMTS and its associated COI also appeared to produce significantly augmented record fire qualification rates. Unfortunately, this investigation uncovered little evidence of an LMTS-to-live-fire relationship.

Future investigations in this line of research should focus on confirmation of the apparent training effectiveness of LMTS and demonstration of an LMTS-to-live-fire statistical relationship. Training effectiveness can be demonstrated conclusively only when prior year Alt-C scores are available. Therefore, it is mandatory that availability of prior year Alt-C scores be a prerequisite for soldier participation in future data collection efforts. Moreover, a fair and rigorous test of an LMTS-to-live-fire statistical relationship can occur only when data collection settings comply with LMTS equipment-use specifications. A valid prediction model can be developed only when the training technology is implemented in proper indoor settings.

Experiment 2

Experiment 2, conducted about 2 months after the first investigation, was also devoted to populating Experimental Group 1 (see Table 1). In common with Experiment 1, all participants received LMTS-based training, used their own weapons with LMTS (to include simulated Alt-C firing), fired all LMTS rounds using the hand-charging procedure described in the first investigation, and went to a live-fire range the following day for qualification firing.

Method

Participants

Sixty-five USAR soldiers of various Military Occupational Specialties (MOSs) completed both the LMTS COI and live-fire phases of this investigation during an Inactive Duty Training (IDT) drill weekend. None of whom had trained with LMTS prior to their participation.

Procedure

With three procedural differences, the LMTS COI in this investigation was identical to the COI implemented in the first investigation (see Appendix A). The first difference was that all training sessions were conducted indoors. Weapon safety, weapon familiarity drills, immediate-action procedures, loading/unloading magazines, front and rear sight adjustments, and application of the four fundamentals of marksmanship were conducted in classroom settings. Battlesight zeroing, engagement of reflective targets, interactive dry firing, and LMTS grouping and zeroing were conducted in an indoor assembly area. The concluding COI exercise (the LMTS Alt-C) was conducted on two improvised 25m ranges that were constructed using hallways at the reserve center.

Indoor administration of the LMTS Alt-C under conditions of controlled illumination resulted in immediate detection (during function pretesting of the laser-sensitive Alt-C target) of an equipment problem. The LMTS laser transmitters, which are attached to M16 barrels via mandrels (see Figure 1), are vibration-sensitive. These devices "read" vibrations that occur each time a weapon's trigger is pulled. If laser transmitters are too sensitively calibrated, they can mistakenly read vibrations from sources other than trigger pulls and thus emit superfluous laser rounds. It was discovered that the lasers in this test were mistakenly reading vibrations that resulted when soldiers' recocked their weapons after each round by pulling back the charging handle. This malfunction was discovered during LMTS Alt-C target pretesting and was easily rectified through a field-expedient solution. In the harsh glare of outdoor lighting during Experiment 1, however, this problem had, in all probability, gone undetected.

The second procedural difference concerned administration of the LMTS Alt-C. In this investigation, two LMTS Alt-C tests were administered to each soldier, consecutively, with a short rest period between the two administrations. Two tests were administered to provide LMTS test-retest data as well as to provide an enlarged measurement domain for predicting subsequent live-fire Alt-C scores.

The third procedural difference was consecutive vs concurrent conduct of the LMTS and live-fire components of the investigation. In the first investigation, all participants completed every phase of LMTS training and testing on the first day, then proceeded en masse to the live-fire range on Day 2. In the present investigation, training sessions were conducted in successive small groups. When the first group completed LMTS training and proceeded to the live-fire phase, other groups were still in various phases of LMTS training. Thus, in the present investigation, after the first half-day, LMTS training and live-fire Alt-C qualification firing were conducted concurrently. The training cadre consisted of eleven instructors from the 84th DIVIT and SATT. Four of whom also served as instructors in Experiment 1.

Results

LMTS Alt-C

Mean scores (N = 65) on the two LMTS Alt-C administrations were 34.88 (SD = 4.90) and 36.28 (3.46), respectively. Although the means differed by only slightly more than one point, the second mean significantly exceeded the first, $t(64) = 2.71$. Scores ranged from 12 to 40 on the first administration and from 24 to 40 on the second. The percentage of soldiers who attained or surpassed the qualification cutoff of 26 hits was 95.4% and 98.5% on the two administrations, respectively. The Pearson Product-Moment coefficient of correlation between the two LMTS Alt-C administrations was a significant $r(65) = .55$.

These LMTS mean scores are substantially higher than the LMTS Alt-C mean (27.49) obtained in Experiment 1. It must be remembered, however, that Experiment 1 LMTS Alt-C scores were probably invalidated by a combination of adverse (i.e., outdoor) environmental test conditions and faulty laser transmitters.

LMTS Remedial Training

Fifty-five of the 65 participating soldiers (84.6%) received remedial training at some point during the LMTS phase of the investigation. ANOVAs indicated no significant differences on any performance measure between soldiers who received remedial training and those who did not.

Live-Fire Qualification

The mean (N = 65) live-fire Alt-C score was 31.78 (SD = 5.79). Scores ranged from 17 to 40, and 83.1% of soldiers (54 of 65) achieved the minimum cutoff of 26 hits on their first qualification attempt. An additional five soldiers achieved qualification on their second attempt, bringing the eventual qualification rate to 90.8% (59 of 65). Of the six soldiers who did not qualify, five did not refire after their initial failure and one refired once but failed to qualify on either attempt. Of the 59 qualifying soldiers, 39.0% earned Marksmanship ratings, 42.4% Sharpshooter ratings, and 18.6% qualified at the Expert level.

LMTS vs Live-Fire

Mean LMTS1, LMTS2, first round live-fire scores, and eventual live-fire scores were (N = 65 in all cases): 34.88 (SD = 4.90), 36.28 (SD = 3.46), 31.78 (SD = 5.79), and 32.66 (SD = 5.14), respectively. (An eventual live-fire score was the first-round score if a soldier did not refire, or the eventual score if a soldier refired. Thus, eventual live-fire scores are always equal to or greater than first-round scores.)

Both LMTS1 and LMTS2 means were significantly greater than the first-round live-fire mean score, with $t(64) = 3.76$ and 5.88 for LMTS1 and LMTS2, respectively. Both LMTS means also significantly exceeded eventual live-fire scores, $t(64) = 2.88$ and 4.87 for LMTS1 and LMTS2, respectively.

Current Year Live-Fire vs Prior Year Live-Fire

Prior year eventual qualification scores were available for $N = 50$ soldiers (Mean = 32.74; $SD = 4.14$). Using t-tests for paired samples, the prior year mean was compared with the current year first-run qualification mean (31.96; $SD = 5.29$) and with the current year eventual qualification mean (32.48; $SD = 4.90$), producing nonsignificant t-values of 1.06 and <1, respectively. (Each test had $df = 49$.) Based on these 50 soldiers, eventual qualification rates were 92.0% and 98.0% for the current and prior years. This difference was not reliable.

Predicting Live-Fire Alt-C

Pearson Product-Moment coefficients of correlation between LMTS-based Alt-C scores and first-round live-fire scores were a nonsignificant $r(65) = .24$ and .19 for first and second LMTS administrations, respectively. Correlations between LMTS and eventual live-fire scores were a nonsignificant $r(65) = .24$ and .07 for first and second administrations, respectively. LMTS1 and LMTS2 Alt-C's were averaged (summed and divided by 2) in an effort to provide a more stable predictor. This summary variable produced a significant $r(65) = .25$ and a nonsignificant $r(65) = .19$ with live-fire first-run and live-fire eventual qualification scores, respectively. To determine the predictive power of LMTS scores (relative to other available predictors), a significant correlation was found between prior year (eventual) and current year (eventual) live-fire scores, $r(50) = .37$, indicating that year-old live-fire scores were a better predictor of current live-fire scores than day-old LMTS scores.

A least-squares linear regression procedure (Norusis, 1993) was used to construct a live-fire prediction model, based upon LMTS1 scores. LMTS1 scores were used instead of the average of LMTS1 and 2, although the latter produced a slightly higher correlation with the criterion measure, due to the fact that in actual implementations of a prediction model, successive administrations of an LMTS-based Alt-C would be highly unlikely. The resulting model took the form:

$$\text{Predicted Live Fire} = B_0 + B_1\,(\text{LMTS1})$$

where B_0 (the intercept) is the theoretical live-fire score for a soldier who scores zero on LMTS, and B_1 (the slope) is the ratio between changes in the predictor and criterion variables. The obtained equation was:

$$\text{Predicted Live-Fire} = 21.950083 + .144732(\text{LMTS1})$$

with an associated $R^2 = .05683$ and $F(1, 63) = 3.80, p = .0558$. The obtained F value, which is a ratio between the regression and residual sum of squares, achieves exactly the same level of statistical significance as the zero-order coefficient of correlation between LMTS1 and live-fire

Alt-C scores, confirming that a relationship exists between the two variables, but that it is a weak relationship. This conclusion is reinforced by calculating 95% confidence intervals around a given prediction. For instance, an LMTS1 score of 28 results in a predicted live-fire score of 29.8, which on first inspection seems reasonable, but the 95% confidence interval for this prediction ranges from 21.7 to 38.0, which is too wide a range to be of much practical use.

Another way to examine the predictive utility of these data is to determine the ability of LMTS1 scores to predict success or failure (i.e., first-round qualification [Q1] vs failure to Q1), using *expectation of success* techniques suggested by Thorndike (1978). In this approach, various cut scores on the predictor variable (LMTS1) are used to predict success (Q1) for every soldier whose LMTS score equals or exceeds the cut score and failure for every soldier below the cut score. For example, the LMTS1 cut score might be set at 30. Soldiers receiving an LMTS1 score greater than or equal to 30 would be predicted to achieve live-fire Q1, while soldiers scoring less than 30 would be predicted not to achieve Q1. Cut scores can be set at any point along the distribution of LMTS1 scores.

With the Thorndike procedure, four outcomes are possible: (1) predicted successes who succeed (correctly predicted success), (2) predicted failures who fail (correctly predicted failures), (3) predicted successes who fail (false positives), and (4), predicted failures who succeed (misses). Thorndike's key index is *hit rate*, or the proportion of correct predictions divided by the sum of both correct and incorrect predictions or, using the four outcome categories above: [(1+2) / (1+2+3+4)]. Table 2 summarizes the results for all possible cut scores and indicates that an LMTS1 score of either 28 or 29 yields the highest possible hit rate for this particular set of data. Cut scores above 30 produce rapidly diminishing hit rates due to the progressive increase in misses, or predicted failures who succeed due to unrealistically high cut scores. Notice the inverse relationship between misses and false positives, which represent two very different kinds of incorrect decisions. Thorndike (1978) points out that the consequences of these two kinds of incorrect decisions (misses vs false positives) can differ considerably depending upon circumstances, and in some instances it may be advisable to adjust the cut score in order to minimize the occurrence of which ever category of mistakes is more costly. For example, under combat conditions false positives (predicted successes who fail) can be quite costly, and this knowledge might convince a combat commander to raise the cut score in order to reduce or even eliminate false positives, even at the cost of increasing the relative incidence of misses.

The relative parity among hit rates for cut scores of 30 or less in Table 2 reflects two influences, the first of which is undoubtedly a weak statistical relationship ($r = .24$) upon which to base the analysis. But another problem intrudes as well (Thorndike, 1978), and that is the fact that predictive devices work best when the event that is to be predicted (Q1 in this instance) occurs with approximately 50% frequency. When the event approaches either zero or 100%, prediction becomes essentially useless. In the second investigation, Q1 was 83.1%, which, for purposes of building a dichotomous (either/or) prediction model, is uncomfortably close to 100%.

Table 2.

Hit Rates for Various LMTS1 Prediction Scores. Success is Defined as Achieving Q1 (A Live-Fire Alt-C Hit Score of at least 26).

LMTS1 Cut Score	Correctly Predicted Successes	Correctly Predicted Failures	Misses	False Positives	Hit Rate (%)
0-23	54	0	0	11	83.1
24	53	0	1	11	81.5
25	53	1	1	10	83.1
26	52	1	2	10	81.5
27	52	2	2	9	83.1
28	52	3	2	8	84.6
29	52	3	2	8	84.6
30	51	3	3	8	83.1
31	47	3	7	8	76.9
32	44	3	10	8	72.3
33	42	4	12	7	70.8
34	40	6	14	5	70.8
35	36	6	18	5	64.6
36	32	8	22	3	61.5
37	29	8	25	3	56.9
38	24	10	30	1	52.3
39	14	11	40	0	36.9
40	6	11	48	0	26.2

Combined Data

Finally, data from this investigation were merged with data from the previous investigation, notwithstanding procedural differences between the two investigations and probable invalidation of LMTS data from the first due to improperly calibrated laser transmitters. Nonetheless, as an exploratory test, data from the two efforts were merged and an overall correlation was calculated between LMTS (LMTS1 only, because LMTS2 was not collected in Experiment 1) and first-run live-fire qualification scores. The resulting significant correlation, $r(149) = .24$, was consistent in both direction and magnitude with results from both investigations.

Discussion

Experiment 2 served to reinforce the conclusion drawn from Experiment 1, that LMTS seems capable of supporting a realistic and comprehensive rifle marksmanship COI. The LMTS-supported COI embodies a high degree of face validity, which is underscored both by the training realism embedded in the system and by the creative application of laser technology to the modern challenge of achieving optimum training benefits while minimizing required resource allocations. The end result is that the LMTS-supported COI has the potential for delivering enhanced training outcomes at the same time that it garners the interest and support of participating soldiers.

A definite strength of LMTS is its ability to identify soldiers in need of remedial training, remove them from the ongoing training process without interrupting the delivery of training to other soldiers, provide the needed remediation, and then return remediated soldiers to the appropriate point in the ongoing COI. In Experiment 1, almost two-thirds of all participating soldiers were provided at least one remedial training session as part of the LMTS COI. In Experiment 2, this proportion grew to over 84%. Moreover, in both experiments, when remediated soldiers were returned to the main COI, they performed on a par with soldiers who were never sent for remediation. This observation does not "prove" the effectiveness of remedial training in LMTS. The only way to prove its effectiveness would be to provide it to some soldiers who need it, withhold it from others, and then compare their subsequent performances. That tact was not possible (or desirable) in either investigation because the LMTS COI is intended to provide remediation to every soldier in need of it. Nonetheless, the obtained outcomes do provide indirect support for the effectiveness of the provided remedial training. Soldiers were selected to receive the training on the basis of observed performance deficits. If the training had been ineffective, these soldiers would have been expected to return to the COI with continuing performance deficits. Such deficits, however, were not manifest in any subsequent performance measures. No significant differences were observed between soldiers who received remedial training and those who did not.

In both experiments, participating soldiers expressed enthusiasm for LMTS-based training. Part of this acceptance is undoubtedly due to the advanced technology that LMTS embodies. Soldiers are fascinated by the cutting-edge technological aspects of the training and this fascination is underscored by the training realism engendered through use of the soldiers' own weapons. Another reason for the high degree of observed acceptance is the nature of the COI itself, which closely follows FM 23-9. The COI contains all the key elements of a realistic and comprehensive rifle marksmanship training package. In the right hands, the COI gets the job done. And this introduces a third critical reason why the LMTS COI has been received so positively by participating soldiers, and that is the training team's expertise. Participating soldiers in both experiments expressed praise for the training team's competence. When the LMTS training package becomes more widely disseminated, it is imperative that a trainer proficiency certification program be fielded along with it in order to ensure a supply of qualified instructors.

Training Effectiveness

More data are needed in order to conclusively determine LMTS' training effectiveness. In Experiment 1, individual soldier qualification scores were not available from the prior year. While it was true that implementation of the LMTS COI was associated with a statistically reliable increase in marksmanship qualification rates (from 63.6% to 92.8%), this increase could not be interpreted unambiguously because the prior year rate was based upon qualification firing that was conducted on a range with pop-up targets. Pop-up targets present a more demanding marksmanship task, so the scoring system is adjusted accordingly. Whereas 26 out of 40 hts are required for qualification on Alt-C, only 23 out of 40 hits earn qualification on a range with pop-up targets. This scoring adjustment is intended to equalize the difficulty of the two qualification venues, but the adequacy of the adjustment process is unknown. For that reason, it is best to say that it appears that implementation of the LMTS COI in the first experiment resulted in a significant increase in marksmanship qualification rates, but that a definitive answer to the training effectiveness question awaits the collection of further data.

In Experiment 2, prior year (eventual) qualification scores were examined, but the scores showed that 98% of soldiers had achieved prior year marksmanship qualification. This extraordinarily high rate of qualification was virtually impossible to improve upon. The observed dip in the marksmanship qualification rate the following year (to 92%) could easily have been the result of statistical regression, or the tendency for groups with extreme scores (high or low) to regress toward the mean on a subsequent test occasion, due to nothing more than measurement error (Campbell & Stanley, 1963). The prior year mean qualification score (32.74), moreover, differed little from the current year (eventual) qualification score (32.48).

Thus, the empirical evidence for training effectiveness is suggestive but inconclusive. Experiment 1 provided partial substantiation of the new technology's effectiveness, but the evidence was inconclusive because of a change in Alt-C venue that could have confounded the observed effect, and an absence of individual soldier prior year data. In Experiment 2, prior year individual soldier scores were available, and firing ranges were consistent for both years, but a prior year ceiling effect may have precluded the possibility of demonstrating training effectiveness. More data are needed, both from experimental units (those receiving LMTS training) and from control units, before the question of LMTS training effectiveness can be answered definitively.

Predicting Live-Fire Qualification Scores from LMTS

Results from both investigations have consistently indicated weak, positive relationships between LMTS and live-fire scores. Only two coefficients edged into the realm of statistical significance, and although those were statistically reliable (indicating that indeed a positive linear relationship exists), they were not of a magnitude to permit practically meaningful predictions of live-fire qualification outcomes. In the first investigation, the relationship was undoubtedly weakened by the fact that training was conducted outdoors, and probably fatally marred by the use of improperly calibrated laser transmitters. In retrospect, it would have been surprising if a robust relationship had been observed in Experiment 1. But in the second investigation, LMTS data collection took place indoors under controlled lighting conditions, and the problem with improperly calibrated laser transmitters was detected and corrected at the target function pretesting stage, yet the strength of the observed relationship between LMTS and live-fire scores was still only $r = .24$, based on LMTS1, and $r = .25$ based on averaged LMTS scores from two Alt-C administrations.

With a training system (LMTS) that so unambiguously simulates the criterion measure (qualification firing), the relationship between the two measures should be stronger. By all accounts, LMTS embodies a high degree of realism. Soldiers train with their own weapons. They fire at targets that are dimensionally identical to live-fire targets. Scoring procedures are identical on the simulated and live-fire Alt-C's. With the accompanying COI, the LMTS component forms part and parcel of a high-fidelity simulated training environment. Yet, LMTS scores were not highly correlated with live-fire qualification scores.

A possible, but unlikely, explanation is that LMTS firing differs in a small but important procedural detail from live firing, and that this small procedural deviation weakens the LMTS-to-live-fire relationship. One procedural difference that has already been identified is that rounds are fired during administration of the LMTS Alt-C by hand-charging the weapon before each trigger pull, whereas on the live-fire range this step is unnecessary because the weapon cycles a new round and recocks itself each time it is fired. It is not likely that this small procedural deviation would weaken a correlation, but it is possible. In any event, this possibility was anticipated and the procedural divergence that presently occurs between hand-charged LMTS rounds and semi-automatic live-fire rounds can be remedied through use of Blazer upper receiver units. Assessing the importance of LMTS semi-automatic fire was planned from the beginning (see Table 1) and will be addressed when the next round of data collection occurs.

A review of the training literature, however, has revealed another (and perhaps more compelling) explanation for the weak correlations between LMTS performance and qualification scores. Schendel, et al. (1985), reported that the Weaponeer marksmanship trainer could be used to predict live-fire performance when marksmanship training was *not* provided immediately prior to Weaponeer testing. When marksmanship training immediately preceded Weaponeer testing, moreover, Weaponeer scores consistently (across three different test conditions) failed to predict subsequent live-fire results. Schendel, et al. (1985) did not conjecture as to the reason for their finding, but it probably represents a statistical artifact known as truncation of range. That is, if two distributions of scores are robustly correlated (as one would expect to find between LMTS and live-fire scores, for instance) and the range of scores in one (or both) of these distributions is truncated (reduced), the result will be reduced variance and a byproduct (a statistical artifact) will be a weakened coefficient of correlation. And that is exactly what intensive training produces: a truncation (or reduction) in the range of scores that otherwise would be observed. Effective marksmanship training eliminates low scores altogether, and bunches remaining scores together and forces them toward the top of the possible range of scores. Thus, intensive training during the LMTS COI, which occurred immediately prior to firing the LMTS Alt-C in the present investigation, may explain the weak correlation between LMTS and subsequent live-fire scores.

And truncation of range on the predictor (LMTS) side of the prediction equation is only half the story. Truncation of range is equally detrimental when it occurs on the outcome measure, and that is exactly what occurred naturally in this instance. The reader will recall that 83.1% of participating soldiers in the second investigation achieved Q1. That is, they fired at least 26 on a 40-point test of marksmanship the first time they tried. That outcome is great for training readiness, but it is not so good for development of a prediction model because it effectively restricts the range of outcome scores.

Thus, two unanticipated circumstances combined to restrict the obtained score ranges of both predictor and outcome variables, thereby producing an attenuated relationship between LMTS and live-fire scores. LMTS scores were systematically restricted through the delivery of a rigorous program of instruction (the COI), and live-fire scores were restricted by use of test units with uniformly high Q1 rates. Either condition would make it difficult to obtain robust statistical relationships, but working together they have proved to be insurmountable. Future research must avoid both circumstances by administering LMTS without prior training and by using an expanded (and hopefully more heterogeneous) sample of participants.

Future research must focus on establishing test conditions where the LMTS-to-live-fire relationship can be assessed rigorously. Only then can the merits of LMTS as a live-fire prediction device be determined. The Schendel, et al. (1985) outcome strongly suggests that a fair and rigorous assessment of the LMTS-to-live-fire relationship can occur only when the LMTS Alt-C component is administered without preceding marksmanship training. A glance at Table 1 will indicate that this condition is not currently represented in the overall research design. Accordingly, an additional (control) cell must be added to the design. In this cell, participants will receive no training, but they will complete the LMTS Alt-C (half with own weapon and half with Blazer) prior to live-fire qualification trials.

Only when the LMTS-to-live-fire relationship is conclusively demonstrated can we proceed to development and implementation of a prediction model that can be used both to identify soldiers in need of sustainment training as well as to determine when sufficient training has been delivered. Moreover, if the obtained relationship between LMTS and live-fire performance is sufficiently robust, it may eventually be possible to replace live-fire qualification with LMTS-based qualification when live-fire ranges are unavailable.

References

BeamHit (1999). *Marksmanship training that works* (Brochure). Columbia, MD: Author.

Campbell, D.T., & Stanley, J.C. (1963). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally & Company.

Commander, Small Arms Training Team (1999). *M16 rifle LMTS (laser marksmanship training system) course of instruction (COI) 990730*. Forest Park (Ft. Gillem), GA: Author.

Dulin, E.G. (1999, January-February). BEAMHIT: This marksmanship training system uses lasers and can go anywhere. *Armor*, 44-46.

Headquarters, Department of the Army. (1989). *M16A1 and M16A2 rifle marksmanship* (Field Manual 23-9). Washington, DC: Author.

Memorandum For Record. (1997, Dec.14). *Small Arms Simulation Training Systems Comparison*.

Norusis, M.J. (1993). *SPSS for Windows Base System User's Guide Release 6.0*. Chicago:SPSS, Inc. Plewes, T. J. (1997, Oct 9). Memorandum entitled *"U.S. Army Reserve (USAR) Weapons Training Strategy for the 21st Century."* Author.

Plewes, T. J. (1997, Nov 24). Memorandum entitled *"U.S. Army Reserve (USAR) Weapons Training Strategy for the 21st Century."* Author.

Purvis, J. W., & Wiley, E. W. (1990). *Trainer's Guide: Personal Computer (PC) Version of the Basic Rifle Marksmanship Program for the Multipurpose Arcade Combat Simulator (MACS)* (Res. Prod. 90-13). Alexandria, VA: U.S. Army research Institute for the Behavioral and Social Sciences.

San Miguel, D. (1998). USARC weapons training strategy for the 21st Century. *The Officer*, 47, 48-49.

Schendel, J. D. (1985, January-February). The Weaponeer and marksmanship. *Infantry*, 32-35.

Schendel, J. D., Heller, F. H., Finley, D. L., & Hawley, J. K. (1985). Use of Weaponeer Marksmanship Trainer in predicting M16A1 rifle qualification performance. *Human Factors, 27,* 313-325.

Scholtes, T. G., & Stapp, K. M. (1994, June). *Engagement Skills Trainer (EST) training effectiveness analysis (TEA)* (TRAC-WSMR-TEA-94-018). White Sands Missile Range, NM: Headquarters, Department of the Army TRADOC Analysis Center.

Schroeder, J. E. (1985). *A multipurpose arcade combat simulator (MACS)* (Tech. Rep. 629). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Thorndike, R.L. (1978). *Correlational procedures for research.* New York: Gardner Press.

Appendix A
The LMTS Course of Instruction (COI)

The current LMTS COI (Commander, 1999) will eventually serve as one part of a comprehensive LMTS Sustainment Skills Training Package (SSTP) designed specifically for the time-constrained Reserve Component (RC) environment. Once completed, the SSTP will: (1) teach soldiers the fundamental elements of rifle marksmanship, (2) increase a soldier's confidence in the ability to use his or her service weapon, and (3) afford more practice opportunities prior to record fire qualification, especially in the range-limited constraints often presented by RC training environments.

The COI is closely correlated with FM 23-9 task requirements (Headquarters, 1989), including M16A2 weapon familiarity drills, immediate-action procedures, loading and unloading magazines, front and rear sight adjustments, application of the four fundamentals of marksmanship (steady position, aiming, breath control, and trigger squeeze), battlesight zeroing, and detecting and engaging a variety of targets (to be described in more detail below) including a timed record fire engagement using laser-equipped weapons and laser-sensitive targets. Remedial training is provided on an as-needed basis as part of the COI.

Although LMTS training is conducted in the "dry fire" mode, soldiers adhere to standard live-fire range commands and weapon safety procedures throughout the training. Safety is consistently reinforced. The COI begins with a safety briefing and safety is emphasized as the most important consideration throughout the training. Soldiers are trained to make on-the-spot corrections for any observed unsafe acts, including calling a "cease fire" when injury or property damage might otherwise result. Additionally, soldiers are briefed on the potential visual hazards attendant to laser technology and specifically instructed never to look directly into any laser emitting device.

Preliminary training on safety, weapon maintenance, and the four fundamentals of rifle marksmanship is conducted in a series of small group, lecture-demonstration sessions. Primary training, held on simulated firing lines, consists of a sequence of progressively more complex target engagement exercises.

Target Engagement Exercise 1: Reflective Targets

This exercise is designed to test a soldier's ability to apply the four fundamentals of marksmanship. The soldier assumes the prone supported position (employing sandbags) and, using his own service weapon equipped with an LMTS laser insert, fires at an LMTS Reflective Zero Target (RZT). The RZT is an actual size representation of the Army standard 25m zeroing target (Figure 2). The LMTS RZT, however, enables an instructor to view, at 25m, laser impacts from soldiers' weapons, and thereby provide the soldier with immediate feedback concerning the adequacy with which he or she has positioned his or her body in the prone supported position, attained proper sight alignment, maintained breathing control, and implemented proper trigger squeeze procedures. The four fundamentals can be evaluated with the laser device in constant ON position, or in training mode, where a single laser beam is emitted following each trigger pull.

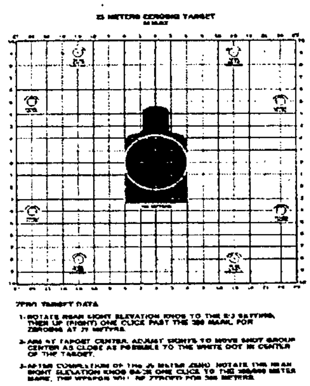

Figure 2. The 25m M16A2 zeroing target.

Target Engagement Exercise 2: Interactive Dry Fire

This exercise is also fired from the prone supported position, but the target is changed from an RZT to a laser-sensitive LMTS TR-700 (Figure 3), capable of detecting and counting the number of laser hits and misses and sending back a visual and auditory signal to the firer.

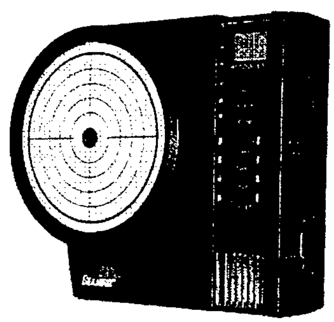

Figure 3. LMTS TR-700 target.

Soldiers fire at the target in sets of 10 rounds, and 8 hits out of 10 rounds are required for a "pass." The COI is designed to require at least two repetitions of the 8 of 10 requirement, but any number of repetitions can be required, and a Military Mask Set of silhouettes can be superimposed on the target to reduce the targeting area and thereby simulate targets at distances of up to 600m.

Following each set of 10 rounds, an instructor inspects the target and evaluates the number and pattern of hits. If the number of hits is less than 8, the instructor performs a visual laser/sight alignment check, reconfirms the soldier's understanding of the four fundamentals of rifle marksmanship, and directs the soldier to fire another set of 10 rounds. If the number of hits is less than 8 after several tries, the soldier leaves the interactive dry firing range and goes to a remedial station.

Target Engagement Exercise 3: LMTS Grouping and Zeroing

For this exercise, soldiers again fire from a prone supported position using their own weapons equipped with a laser insert. Targets are computer-supported LMTS TR-900 laser-sensitive devices (Figure 4) with superimposed 25m silhouettes that dimensionally replicate the 25m zeroing target (Figure 2). The computer linked to Exercise 3 targets is loaded with software that detects the precise point of impact of each laser round and calculates center of mass and maximum dispersion of each shot group.

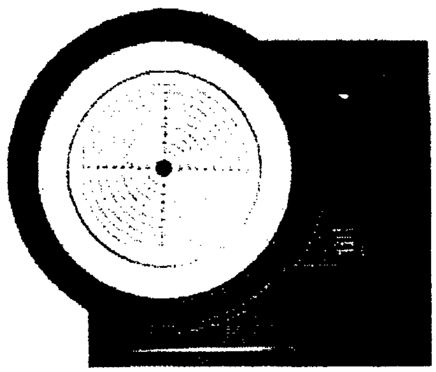

Figure 4. LMTS TR-900 target.

In the grouping phase of the exercise, soldiers may fire up to 27 rounds in 3-round shot groups. Satisfactory grouping is demonstrated when two consecutive 3-round shot groups (measured separately) fall within, or on the border of, a 4cm circle. If a soldier is unable to achieve this standard within 27 rounds, he or she is sent to a remedial station and then is permitted to return subsequently to start anew on the grouping exercise.

Once satisfactory grouping is demonstrated, the soldier adjusts his or her sights to bring shot placement within the (center) 4cm circle on the 25m zeroing target. The soldier fires 3-round shot groups (up to a maximum of 18 rounds), adjusting sights as necessary between groups. When a shot group falls within, or on the border of, the 4cm circle, the soldier fires an additional shot group for confirmation. Zeroing is satisfactorily demonstrated when a minimum of five rounds in two consecutive 3-round groups fall within, or on the border of, the 4cm circle.

Remedial Training

Remedial training, consisting of a systematic check on the soldier's ability to apply the four fundamentals of marksmanship to the integrated act of firing an M16 rifle, begins with a careful weapons serviceability check and proceeds to an evaluation of the soldier's prone supported and unsupported firing positions, sight alignment picture, trigger squeeze technique, and use of proper breath control. Once the remediation instructor is satisfied that the soldier understands the four fundamentals, the soldier is directed to demonstrate their application using RZT's as described above in Exercise 1.

Once the soldier properly performs the four fundamentals using RZT's, the instructor then explains how the fundamentals are integrated into the act of firing.

Depending on the judgment of the instructor, the soldier may then be re-entered into the formal COI at Exercise 2 (Interactive Dry Fire), or at either the grouping or zeroing phase of Exercise 3. Theoretically, soldiers may be pulled from the formal COI sequence any number of times, although the evaluative and corrective procedure is designed to produce problem recognition and remediation in one coordinated session.

Target Engagement Exercise 4: Simulated Qualification: The 25m Alternate Course "C" (LMTS Alt-C)

A properly zeroed weapon is the prerequisite for this exercise (see grouping and zeroing procedures in Exercise 3 above). Soldiers fire from prone supported and unsupported positions using their own weapons equipped with a laser insert. The target consists of an electronic Alt "C" Target (Figure 5), which presents an array of 10 scaled silhouettes, ranging from 50m to 300m. This target dimensionally replicates the 25m live-fire Scaled Alternate Course qualification target (Headquarters, 1989; Appendix G.) Soldiers fire two (laser) rounds at each silhouette from a supported position (20 rounds), followed by two rounds at each silhouette from an unsupported position, for a total of 40 rounds. The target array is linked to a computer, which counts and records the number of laser hits on each silhouette. Twenty-six to 32 hits result in qualification at the Marksmanship level. Sharpshooter status is achieved with 33 to 37 hits, and 38 or more hits merit an Expert rating.

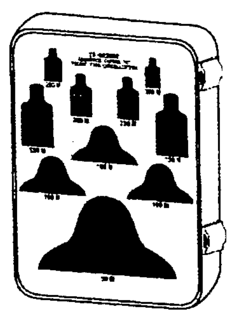

Figure 5. The LMTS electronic Alt-C target